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ELECTROMAGNETIC CHUCK CONTROL CIRCUIT

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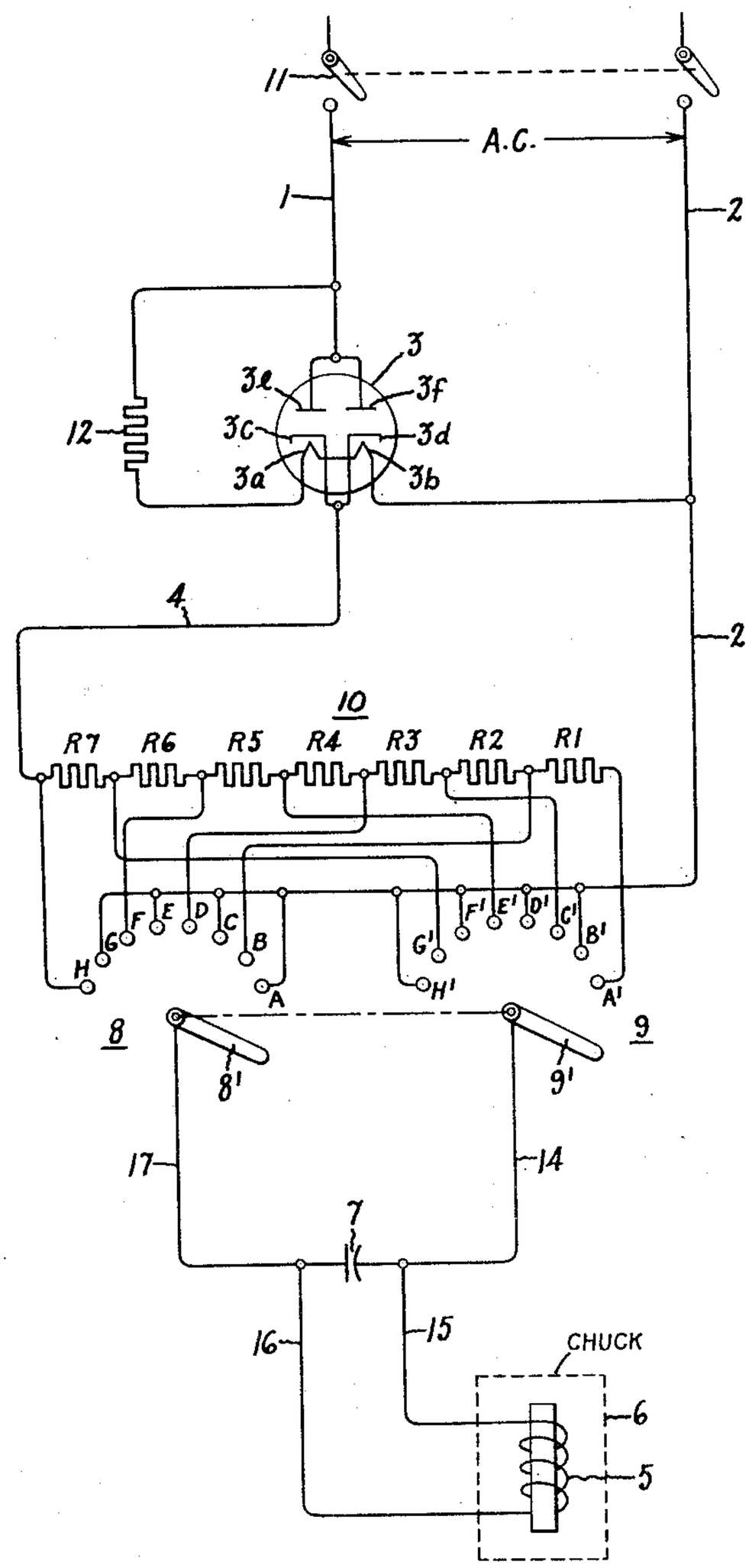

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ELECTROMAGNETIC CHUCK CONTROL CIRCUIT

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This invention relates to circuits of the type used for controlling the amount of magnetism in an electromagnetic device and more particularly to circuits for the control and demagnetization of electromagnetic chucks from a source of unidirectional current. The invention has for an object the provision of an improved circuit for the magnetization, holding, and demagnetization of electromagnetic chucks.

Electromagnetic chucks are widely used for securing work-pieces on lathes, planers, grinding machines and the like, and require unidirectional current for the energization of the coil of the chuck. A difficulty encountered in the use of electromagnetic chucks is that it may not be possible to remove the work-piece from the chuck after the current has been turned off because of the residual magnetism of the chuck and work-piece. In order to overcome this difficulty, many systems have been used. Such systems generally include a device for gradually reducing the magnitude of the unidirectional energizing current and a separate device for commutating such current during the period of reduction. It is an object of my invention to provide a single device which performs both of these functions simultaneously.

A further object of the invention is to provide a control circuit for an electromagnetic chuck which is simple and reliable in operation and at the same time is inexpensive to produce.

In carrying out my invention in one form, I provide a source of alternating current energy which is rectified by a duo-diode electron discharge device to produce unidirectional current for energizing the coil of the electromagnetic chuck. Connected in series with the coil of the chuck across this supply of unidirectional current is a combined current varying and current reversing mechanism comprising two rotary step type switches and a multi-section resistor. The two rotary switches are operated in synchronism by a common operating mechanism. The movable rotary contact arms of the two switches are connected to the two terminals of the coil of the electromagnetic chuck. Alternate fixed contacts of each rotary switch are connected directly to one side of the unidirectional current supply and the remainder of the fixed contacts on the switches are connected progressively and alternately to successive intermediate junctions on said resistor which is connected to the other side of the unidirectional current supply, so that in energizing the electromagnetic chuck the current through the coil thereof is reversed at each step

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and the circuit is completed through progressively less resistance at each step. On de-energization of the electromagnet, the reverse process occurs so that the electromagnetic chuck is subjected to a gradually decreasing amplitude, reversing-polarity current. Connected in parallel with the electromagnetic chuck across the two movable contact arms is a capacitor which serves as a filter capacitor for the rectifier circuit and as an arc suppression capacitor for the two rotary step switches.

For a more complete understanding of my invention, reference should be had to the accompanying drawing, the single figure of which is an electrical circuit diagram of one preferred embodiment thereof.

Referring to the drawing, the alternating current electrical energy to operate the electromagnetic chuck and its associated control circuits is derived from conductors 1 and 2. Connected to conductor 1 is a duo-diode electron discharge rectifier 3 which converts the alternating current to the unidirectional current which is required for the energization of the electromagnetic chuck. Unidirectional current is supplied to the chuck and the remainder of the system through conductors 2 and 4.

A coil 5 of an electromagnetic chuck 6 is connected to this source of unidirectional current through terminal conductors 15 and 16. A capacitor 7 is connected in parallel with coil 5. Connected in series with coil 5, across conductors 2 and 4, are two rotary step switches 8 and 9 arranged for unicontrol operation and a multi-section resistor 10, composed of sections R1 to R7 inclusive.

To initiate the operation of electromagnetic chuck 6, switch 11 is closed to energize conductors 1 and 2 with conventional alternating current at consumer's voltage. This energizes heaters 3*a* and 3*b* of electron discharge device 3 through a current limiting resistor 12. After cathodes 3*c* and 3*d* have been heated by heaters 3*a* and 3*b*, electron discharge device 3 is ready to function as a half-wave rectifier and convert the alternating current supply to the unidirectional current which is required to energize coil 5 of the electromagnetic chuck. A double diode rectifier 3 is used in this case merely to provide increased current carrying capacity, with two anodes 3*e* and 3*f* being used in conjunction, respectively, with the two cathodes 3*c* and 3*d*.

It should be understood that although I have illustrated and described a particular rectifier suitable for supplying unidirectional current to

the chuck, any rectifier device of suitable current and voltage characteristics may be used. Other conventional sources of unidirectional current such as batteries, for example, may also be used to operate the chuck.

To begin the energization of coil 5 of electromagnetic chuck 6, movable contact arms 8' and 9' of rotary step switches 8 and 9 are moved, respectively, to positions A and A' where they make contact with the fixed contact members at these positions. Rotary switches 8 and 9 have an equal number of steps and are operated in synchronism by a common operating mechanism. The rotating contact members 8' and 9' of the two switches are electrically conductive and form one terminal of each of the switches. The fixed terminals or contacts of switches 8 and 9 are indicated, respectively, by A to H inclusive, for switch 8, and A' to H' inclusive, for switch 9.

When rotary member 8' is moved to position A and rotary member 9' is simultaneously moved to position A', coil 5 is energized with unidirectional current through all cumulatively connected sections of resistor 10. The circuit is completed from conductor 4 through resistor 10 to contact A', through member 9' and conductors 14 and 15, thence through coil 5 and through a return circuit including conductors 16 and 17, and rotary member 8', back through contact A to conductor 2. This energizes coil 5 at the lowest value of magnetization. When switches 8 and 9 are advanced to the next step, which brings movable members 8' and 9' in contact, respectively, with contacts B and B', the current through the coil 5 is reversed, and simultaneously is increased, due to the fact that section R1 of resistor 10 is eliminated from the circuit. At this step, coil 5 is energized from conductor 4 through sections R7 to R2 inclusive, of resistor 10, through contact B and member 8', conductors 17 and 16, and back through conductor 15, conductor 14, member 9' and contact B' to conductor 2.

Thus, it can be seen that one section of resistor 10 is eliminated from the series circuit for each step which rotary step switches 8 and 9 are advanced in the counterclockwise direction, so that the current through coil 5 is increased at each step, while the direction of current flow simultaneously is reversed at each step. To secure the maximum magnetic pull, the two switches are advanced counterclockwise through successive steps until movable member 8' is engaged with contact H and the movable member 9' is engaged with contact H'. When contacts H and H' are reached, resistor 10 has been entirely eliminated from the circuit and coil 5 is energized directly from conductor 4 through member 8', conductors 17 and 16, and back through conductors 15 and 14 and member 9' to conductor 2.

To de-energize electromagnetic chuck 6 and the work-piece (not shown) which it may be holding, rotary switches 8 and 9 are operated through their common operating mechanism in the reverse or clockwise direction from contacts H and H' toward A and A', respectively. When the two switches are operated in this direction, the opposite of the energizing process occurs. An additional section of resistor 10, beginning with section R7, is inserted in series with coil 5 at each step and the current is simultaneously reversed at each step so that coil 5 is subjected to a gradually decreasing amplitude reversing-polarity current. After the electromagnetic chuck 6 and work-piece have been de-energized in this manner, the work-piece can be removed from the chuck with very little effort.

Each of the sections of resistor 10 has a different value of resistance in order to provide a substantially uniform change in magnetization or de-magnetization for each step of switches 8 and 9. The resistance of each section increases progressively from section R7 to R1 and the resistance value of each section is chosen in conjunction with the other elements of the circuit to provide a uniform change with each step in the magnetic force exerted by coil 5.

Capacitor 7, which is connected in parallel with coil 5, functions as a filter capacitor for the single phase half-wave rectifier circuit and at the same time functions also as an arc suppression capacitor for switches 8 and 9. This arrangement minimizes the number of capacitors required for the control circuit and at the same time makes it possible to use small, light and inexpensive step switches, because arcing across their contacts is suppressed by capacitor 7.

A feature of my invention is its suitability for holding work-pieces in the chuck with less than the maximum magnetic pull, if so desired. This can be accomplished, without any additional equipment merely by rotating switches 8 and 9 to one of the intermediate positions such as E—E' instead of to the fully energized position H—H'. This feature is important, for example, for holding thin material which might be deformed if subjected to maximum magnetic pull.

While I have illustrated and described one preferred embodiment of my invention, many modifications will occur to those skilled in the art and, therefore, it should be understood that I intend to cover by the appended claims any such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A control circuit for operating an electromagnetic chuck from a source of unidirectional current comprising, two step switches having equal numbers of steps, each of said switches having a quantity of fixed contacts equal to the number of steps and a movable contact arm for successively engaging said fixed contacts, means connecting said arms for unicontrol operation, a number of resistor sections equal to one less than said number of steps, alternate fixed contacts of each switch being connected directly to one side of said current source, the remaining fixed contacts of said switches being connected progressively and alternately through a progressively varying number of cumulatively connected resistor section to the other side of said current source, the operating coil of said electromagnetic chuck being connected between the moving contact arms of said two step switches, whereby the current through said chuck is reversed and the circuit to said chuck is completed through a different amount of resistance at each concurrent step of said switches, and a capacitor connected in parallel with said operating coil for filtering said unidirectional current and for surpressing arcing between said fixed and movable contacts.

2. In combination, an electromagnetic chuck having an operating coil, connections to a source of unidirectional current, and selective means for energizing said operating coil with a predetermined amount of unidirectional current derived from said source and for varying and

simultaneously commutating the current to said operating coil, said means comprising two step switches operable in synchronism by a common operating mechanism and a plurality of serially connected resistor sections, the odd fixed contacts of one said step switch and the even fixed contacts of the other step switch being connected directly to the same side of said source of unidirectional current, the remaining fixed contacts of said step switches being connected progressively and alternately through a progressively changing number of said cumulatively connected resistor sections to the other side of said source, and said operating coil being connected between the moving contact arms of said step switches.

3. A control system for magnetizing and demagnetizing an electromagnet from a source of unidirectional current including selective means for providing said electromagnet with a predetermined amount of unidirectional current and for varying and simultaneously commutating said unidirectional current, said means comprising two multi-step switches operated in synchronism by a common operating mechanism, and a plurality of resistor sections, alternate fixed contacts of each of said switches being connected to the same side of said source of unidirectional current, the remaining fixed contacts of said switches being connected progressively and alternately through a progressively varying number of cumulatively connected resistor sections to the other side of said source.

4. A control system for operating an electromagnetic chuck having a unidirectional current operating coil comprising, connections to a source of unidirectional current, two rotary step switches having equal numbers of steps, each of said step switches comprising a plurality of arcuately positioned fixed contacts equal to the number of said steps and a rotatable contact member movable to engage a selected fixed contact, said movable contact members being operable in synchronism by common operating mechanism, a multi-section resistor having a quantity of serially connected sections equal to one less than said number of steps, each said resistor section having a different value of resistance, said values increasing progressively from one end of said resistor, and a combined arc surpression and filter capacitor for surpressing arcs resulting from the operation of said step switches and filtering the unidirectional current from said source, said capacitor and said operating coil being connected in parallel across the movable contact members of said two rotary switches, the odd fixed contacts of one rotary switch being connected to one side of said source of unidirectional current, the even fixed contacts of the other rotary switch being connected to said one side of said source, the remaining fixed contacts of both rotary switches being connected alternately and progressively to successive intermediate junction points between said resistor sections, said one end of said resistor being connected to the other side of said current source, whereby when said switches are operated in synchronism, the current through said operating coil is progressively varied and simultaneously reversed at each successive concurrent step of said rotary switches, the resistance values of said resistor sections being such that an approximately uniform change in magnetic pull of said electromagnetic chuck results from each step of movement of said switches.

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